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ABSTRACT

School districts have begun examining the feasibility of, and in some cases are developing and implementing automated systems for, managing and evaluating instructional programs. This paper describes and analyzes the issues and problems that emerged over the course of three projects--a large suburban school in the West, a consortium of five small schools in the East, and an Army division in the Northwest--which were directed toward designing, developing, and implementing computer systems for managing and evaluating educational programs. Discussion is organized in four parts: (1) an overview; (2) a description of the approach and concepts; (3) insights into project successes and failures; and (4) recommendations for future directions. The overview covers the common objectives of systematizing and facilitating access to information for program management, supporting program improvement efforts, and providing evaluative information to assess program outcomes and effectiveness. A general systems model is used to describe the approach and concepts and to illustrate the organizational complexity of the projects. Potential conflicts between the goals of groups within the system and problems associated with the hierarchical structure of authority and responsibility are noted. Insights into the utility of a general systems approach are discussed in the context of synergism, system structure, optimization, stability, and equifinality. It is recommended that the development process be structured to (1) facilitate the functioning of relevant parties so that the overall goal is achieved; (2) contribute to communication and feedback among all parties; (3) consider the needs of all parties; and (4) gather information on system functioning for revision and improvement. (DJR)

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Problems and Issues in Using Emerging Computer Technologies to Manage and Evaluate Instructional Programs 1,2,3

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With the emergence of microcomputer technologies, school districts have begun examining the feasibility of, and in some cases, are actually developing and implementing automated systems for managing and evaluating instructional programs. (See, for example, Williams and Bank, 1984). This paper describes and then analyzes the issues and problems that emerged over the course of three projects directed toward designing, developing and implementing computer systems for managing and evaluating educational programs. The innovative aspect of these analyses lies in the application of the concepts and principles from General Systems Theory (von Bertalanffy, 1968) as an organizer for understanding project strengths and weaknesses and for identifying strategies for future development activities. This perspective evolved over the course of experience with the projects and provided a useful framework to guide planning as the view became articulated.

More specifically, the discussion is organized into four parts. First, an overview of the three projects is provided to give the reader a sense of the implementation contexts for the projects. Second, a description of the approach and concepts drawn from General Systems Theory is presented. Third, insights into project successes and failures are illustrated organized around principles drawn from the general systems perspective. Finally, recommendations for future directions that may be productively taken in developing instructional information systems are considered.

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Overview of Projects

The implementation settings and stages of project completion for the three projects are very different. One project is being conducted in a large urban school district in the Western United States and is currently in the development stage. A second project is being carried out under the auspices of a consortium of five small suburban school districts in the Eastern United States and is currently in the design phase. The third project was located at an Army division in the northwest United States and is essentially complete.

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Despite their apparent diversity, all three projects share common objectives. More specifically, they are directed toward developing computerized management information systems: 1) to systematize and facilitate access to information required for program management by decision-makers; 2) to support program improvement efforts by providing information on participant needs and program strengths and weaknesses; and 3) to provide evaluative information on participant performance in order to assess program outcomes and effectiveness.

While the specifics of hardware and software differ across the three systems, they include similar features: 1) a networked system linking users at various levels of the institutional hierarchy; 2) an integrated data base containing a broad range of information required for management and evaluation purposes; 3) a relational data base management system to reduce programming requirements and to increase the flexibility of reporting formats, and 4) the use of electronic devices (such as optical scanners and electronic clipboards) to minimize data entry requirements.

The development teams for the three projects are attempting to strike a balance between technological and human considerations. On the technological side, they are capitalizing on emerging microcomputer and other electronic technologies to build powerful systems. On the human dimension, they are attempting to pay careful attention to user needs, to explicitly consider human factors, and to nurture a psychological climate that will foster the credibility and acceptance of these innovations.

Some aspects of these projects are working well, others are not. Insights into the reasons why can be gleaned when the experiences are considered from the vantage of a general systems perspective.

An Approach Based on General Systems Theory

Systems theory encompasses a vast range of issues and approaches ranging from philosophy to mathematics, to empirical research on systems behavior, to systems engineering (Mattesich, 1982). At the heart of systems thinking is an emphasis on input-output features, a purposeful orientation with concerns for means-ends relationships, and feedback loops within the system to adjust the behavior of system components to yield the desired end-behavior of the entire system (see, for example, von Bertalanffy, 1968.) The essence of systems thinking lies in a wholistic, non-linear view that constantly relates components of the system back and forth to the overall system and tries to reconcile their often conflicting goals.

For the purposes of this discussion, Figure 1 presents a

general systems model for the most organizationally complex of the three projects. There are two major system components: the project sponsors-users and the project developers. The project sponsors-users consist of five school districts loosely organized into a consortium by virtue of each superintendent's membership in a joint council of school superintendents whose districts are in close proximity. Within each district, there are several sub-systems relevant to the project: school board members (representing community members and parents), district administrators, school administrators, and teachers. The developers are located at two universities (the University of Pennsylvania and the University of California) which formed a project team. Within each development group, there are also relevant sub-systems: management and educational policy specialists at the University of Pennsylvania and management, instructional specialists, and computer specialists at the University of California.

The purpose driving the system in Figure 1 is the development of a comprehensive information system that will serve a broad range of information needs for program management and evaluation. However, there is inherent tension and potential conflict between the goals of groups within such a system. For example, school board members and district administrators require information that is comparable across schools within their district and across similar districts in order to make comparisons for accountability purposes. Thus, accountability reporting to external agencies and the public brings a need for uniform data collection designs that remain relatively static over time. On the other hand, teachers have a need for detailed information on student outcomes (skills) tailored to their particular instructional program and curricular materials for use in planning instruction. This information must be sensitive to classroom expectations and resources, adaptive to unplanned changes, and carefully timed to be available within the required planning timeframe.

The formally established communication mechanisms within the system are complicated. Within each district, there is a hierarchical structure of authority and responsibility with communication generally occurring within the same level of the organization (i.e., teachers talk to each other) or at the level just above in the reporting chain (principals talk to teachers and vice versa). Further, the primary formal communication mechanism among districts is the Superintendent's Council which meets bi-weekly. Given the natural bureaucratic barriers to communication, there is limited informal communication or coordination among districts (or among sub-groups within a district). The primary communication link between the district consortium and the university developers is the Superintendent's Council. One member of the University of Pennsylvania development team serves as facilitator of the Superintendent's Council and is the primary liaison between the districts and the developers.

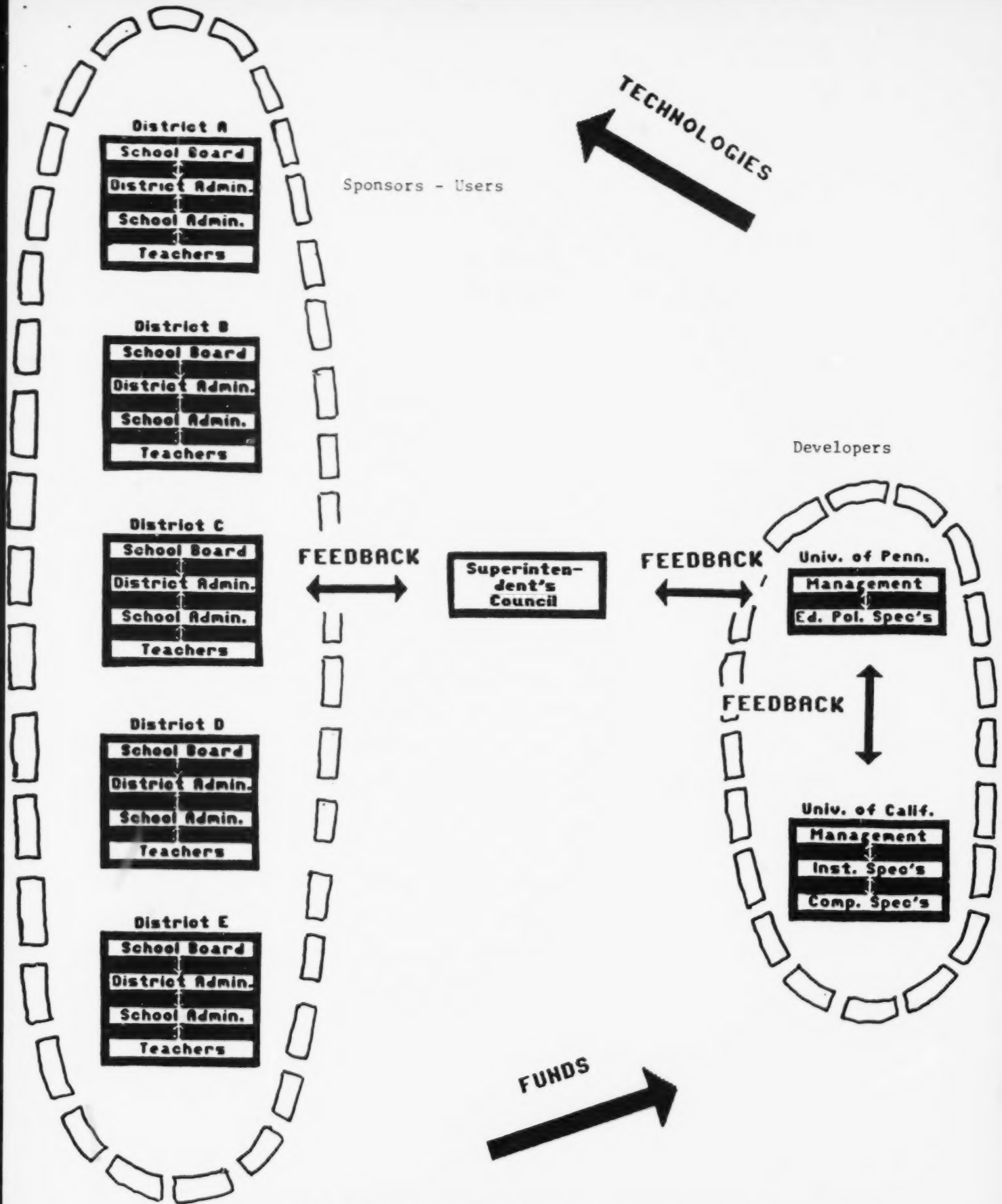

Figure 1. General Systems Model for Development of an Instructional Information System.

The arrows in Figure 1 underscore the importance of interchange among system components and feedback loops in order for such a complex system to function in a healthy and productive manner. On the face of the agreements, the district consortium is to provide funds and identify needs and requirements for the management information system; the university developers are to provide the technology. However, from a general systems perspective the feedback loops between the districts and the developers (as well as those between sub-systems within these components) are the vital mechanism for project success. These communication and coordination mechanisms are critical in order for the resulting innovation to be objectively valuable (i.e., meets the needs and requirements of users) and to be psychologically valued by all concerned parties.

Insights into the Utility of A General Systems Approach

Principles drawn from General Systems Theory provide a useful framework for understanding the strengths and weaknesses of these development projects. These principles are outlined below with illustrative examples of the types of issues that have emerged in the three projects.

Synergism. As integration among system components increases, synergistic effects (i.e., synchronized energy) are more likely to occur. Extensive communication among system components, in this case, sponsors-users and developers of the management information system, are needed to develop the strong, well defined interrelationships required for integration to occur. This dialogue must yield mutual understandings and acceptance of relative roles and working relationships.

One strategy for building such synergism was an ongoing series of planning meetings held in order to encourage communication among representatives of all interested parties and to develop common understandings of and expectations for the planned system. In addition to the developers, these meetings included the following representatives from each of the five districts: two school board members, the District Superintendent and a member of his district administrative staff, the principal and a member of his or her school administrative staff from the two schools selected to participate in the project, and two teachers from the grade levels targeted for initial system implementation (upper elementary) from each of the two participating schools.

Participants in this series of day and a half meetings were organized into small working groups for in-depth discussion. Each participant had the opportunity to meet with those from

other districts assigned to provide a cross-section of individuals from each sub-group (i.e., board members, district administrators, school administrators, teachers, and developers) and to meet with those representatives from his or her own district. Initial meetings were directed toward identifying critical needs facing their districts and schools, specifying the types of information that would be useful in addressing these needs, and considering how such a comprehensive information system would be useful in performing each person's role. Subsequent meetings addressed specific data elements to be included in the system and reporting formats that would display the information in a useful form.

A strength of these early meetings was that they stimulated a dialogue among individuals both across districts and within each district who rarely, or in some cases if ever, communicated with each other. For example, school board members and teachers had an opportunity to sit down face to face and share their perceptions of the key educational issues facing their districts and schools and to identify the types of information which they felt would be helpful in planning solutions. These discussions generated considerable excitement and commitment to the project.

A weakness of the approach as implemented was that the synergistic energy generated as a result of these meetings was not adequately channeled so that some of the synergism dissipated over time. Over the course of the project, meeting schedules became irregular with the ebb and flow of other commitments and deadlines for agreed upon products slipped. In retrospect, the working meetings were a critical element in igniting enthusiasm for the effort and forging working relationships among parties within the system. However, greater regularity of meetings and greater accountability of working groups and individuals charged with specific responsibilities were needed to sustain the synergism.

System structure. The clearer the vertical and horizontal structure, the more the system is in control and the more persons and activities within the system are vested with purpose and meaning. Again, the communication and feedback loops within the system properly used can serve to clarify the system structure and yield common understandings of the respective responsibilities of components within the system.

Formal designation of responsibilities and reporting relationships is a critical mechanism for clarifying system structure. For example, in one project a coordinator (usually a district administrator) was designated within each district to facilitate project development and implementation in his or her district. He/she was charged with organizing all meetings within the district, assigning responsibilities to individuals within the district and holding them accountable, and serving as primary liaison with the development team. In addition, a teacher at

each participating school was designated as project leader for his or her school. He/she was charged with serving as project liaison with other teachers at the school to insure that the project was understood and their input gathered.

While such designations and allocations of responsibilities helped to clarify the roles and expectations of groups within the system, it became readily apparent that appropriate incentives were required to make such participation workable. In particular, district and school administrators as well as teachers were overloaded with responsibilities and time commitments prior to the project. Many felt extremely constrained in the time and energy which they could devote to the project and some felt that their participation was a burden and obligation with a likely payoff that was not worth the effort. In cases where incentives were structured to allow and to encourage participation in the project (e.g., release time for teachers, reassignment of selected duties of administrators in recognition of the time demands for this project), fuller and more meaningful participation was achieved.

Optimization. If sub-systems operate to optimize their own individual performance, the net result will almost never be overall system optimization. Thus, in order to achieve overall success, system components must embrace the overall system goal, agree to cooperate, and devise strategies for accomplishing unique organizational goals within the larger context of the system goal. Thus, project parameters must be negotiated jointly to ensure that the interests and needs of component organizations within the system are at least partially incorporated and a sense of ownership created among all parties within the system.

A primary point of negotiation in these projects centered around data elements to be included in the system. In one project, five categories of data to be included in the system were jointly agreed upon based on the results of working meetings and consensus achieved through a modified Delphi technique: achievement outcomes, other student outcomes (e.g., writing, self-concept), student characteristics, classroom processes, and parent/community involvement. Within each of these areas, districts were constrained to agree on a specified number of common data elements per category and were allowed to identify a specified number of unique data elements per category.

Coming to agreement on common elements across districts and unique elements within districts was a difficult task. Districts had different needs and concerns (e.g., one district served primarily a working class, ethnically mixed community and was concerned with issues of equity and intergroup relations, another served a primarily white, upper middle class community and was concerned with issues of academic excellence and comparability with private schools in the area). Further, within each district, sub-groups differed in the type, specificity, and level of

aggregation of desired information (e.g., teachers wanted extremely detailed, descriptive information on individual students for diagnostic purposes, while school board members were more interested in more global assessments at the grade, school building, or district level which could be used as benchmarks to assess their district vis a vis other similar districts). Accommodation of both "top-down" and "bottom up" needs (Baker, 1983) is critical to developing a system that is credible to all sub-groups within the system and increases the liklihood of obtaining reliable and valid data since the primary data providers (generally teachers and students under the supervision of teachers) have a vested interest in the success of the project.

Stability. All systems tend to have mechanisms for maintaining a steady state. This tendency leads to the well-recognized resistance to instructional innovations (Berman & McLaughlin, 1977) and implies a need for planning to anticipate the problem. Such planning should establish organizational supports for re-establishing stability after the introduction of the innovation.

In these projects, a modular development and implementation strategy was adopted in order to make the problem of re-establishing stability after introduction of the instructional information system more manageable. For example, during the first year of one project, a prototype system was developed with a limited number of data elements restricted to two schools per district and two grade levels within each school. By restricting the system scope, the project could be closely monitored to ensure that the system was meeting the needs of users and compatible with daily operations and to identify areas for improvement.

In order to reduce resistance to the project and preferences for "business as usual", it also became important early on to demonstrate the potential utility of the system to users, to reduce their anxiety about the uses to which information would be put and allay concerns about demands that the system would place on their time. Satisfying these concerns required extensive interaction between the development team and potential users to design reports to meet user needs, to develop a security system to restrict data access and protect privacy, to build procedures (e.g., use of optical scanners) to minimize data entry load, and to build user-friendly software to minimize training time for users.

Equifinality. The final state of an open system can be reached by starting from a number of different initial starting conditions and through a variety of means. As the number of alternatives increases, the system is more able to adjust to unforeseen changes in the environment and to accomplish its purposes. Thus, multiple options increase the adaptive

flexibility of an effort.

Perhaps the greatest contribution to equifinality in these projects came from the use of an off-the-shelf, commercially available relational data base management system (RDBMS). The RDBMS can be used to create databases, update and retrieve data, and write reports. In addition, menus were created for specific applications to facilitate use. Using such an RDBMS avoided the need to spend time and money to develop complex customized computer software and offered great flexibility in answering queries that could not be anticipated.

Future Directions

A general systems view of the process of developing an instructional information system implies that the development process should be structured to facilitate functioning of relevant parties so that the overall project goal is achieved, to contribute to communication and feedback among all parties, to consider the needs and concerns of all parties, and to gather information on system functioning for revision and improvement. More specifically, the process should include:

- an explicit consideration of the goals and information needs of potential users with joint negotiation and agreement on system parameters;

- definition of the role of the development team as a collaborative one with anticipated users so that needs and requirements for the planned system are jointly understood at each step of the process (i.e., avoidance of the role of developers as providers of a turnkey system);

- an ongoing formative evaluation of the development process itself as well as the resulting management information system, with particular concern for capturing ongoing communication and feedback mechanisms among all parties and identifying improvement strategies;

- a modular development strategy with initial implementation of small-scale system limited in its scope of users with ongoing interaction and training activities to build a base of support among users and to develop implementation procedures which can be easily incorporated into ongoing operations;

- long-term, multi-year agreements to allow for the growth of trust and credibility, the development of productive working relationships, and sufficient time for the extended development cycle encountered in projects with a high degree of technological complexity to run its course; and

o a full documentary base for the project to inform subsequent decisions and to provide a full record of intentions and accomplishments in order to understand system functioning and to provide a vehicle for additional project-related or other follow-on efforts.

It is hoped that such a strategy will contribute to the development of high-quality instructional information systems useful for "top-down" and "bottom-up" information needs. Furthermore, documentation of the process will help to identify the state-of-practice and will contribute toward a research base that can be used to assess the state-of-the art of such systems.

Footnotes

1. This paper was presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA, 1986.

2. The opinions expressed in this paper are the views of the author and do not represent an official U.S. Department of the Army position.

3. The author would like to acknowledge the contribution of Dr. Jack H. Hiller in structuring the general systems view presented in this paper and providing helpful comments and reactions.

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